ORIGINS OF CHINOOK SALMON (*Oncorhynchus tschawytscha* Walbaum)

IN THE YUKON RIVER FISHERIES

1983

By

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October 1984

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ABSTRACT

Linear discriminant analysis of scale patterns and age composition data of chinook salmon *(Oncorhynchus tschawytscha* Walbaum*)* from the spawning escapements and catches in the Yukon River were used to allocate Districts 1, 2, and 3 commercial harvests to geographic region (run) of origin. Estimates of run contribution to the Districts 1, 2, and 3 subsistence fisheries were based on trends in run composition of the commercial catches. Upriver catches were apportioned based on geography. The total 1983 Yukon River harvest of chinook salmon was 105,565 (51.4%) upper Yukon, 744,859 (36.4%) middle Yukon, and 25,036 (12.2%) lower Yukon fish.

KEY WORDS: Chinook salmon, *Oncorhynchus tschawytscha*, stock separation, catch and run apportionment, linear discriminant analysis.

INTRODUCTION

The Yukon River chinook salmon *(Oncorhynchus tschawytscha* Walbaum*)* commercial fishery is one of the largest in Alaska. The combined Alaskan and Canadian annual harvest averaged 104,738 fish during the period 1962 to 1982, ranging from a low of 77,224 to an all time high of 157,509 in 1981. While chinook salmon are commercially harvested virtually throughout the entire length of the Yukon River, an average of 70% of the catch is taken in the District 1 gillnet fishery which operates in the lower 101 km of the river (Figures 1 and 2). Another 20% of the annual harvest is regularly taken in the District 2 commercial fishery. The average annual harvest by subsistence fisheries along the Yukon River was 25,373 chinook salmon between 1962 and 1982. Most of the subsistence harvest is taken with fishwheels and gillnets in Districts 3, 4, and 5. In 1983, a total of 215,815 chinook salmon were harvested, of which 138,686 fish (64%) were taken by District 1 and District 2 commercial fishermen.

Chinook salmon harvested in the Yukon River fisheries are a mixture of stocks destined for spawning areas throughout the Yukon River drainage. Although more than 100 spawning streams have been documented (Regnart and Geiger 1982), aerial surveys of chinook salmon escapements indicate that the largest concentrations of spawners occur in three distinct geographic regions: (1) tributary streams that drain the Andreafsky Hills and Kaltag Mountains approximately between river miles 100 and 500; (2) Tanana River tributaries approximately between river miles 800 and 1,100; and (3) tributary streams that drain the Pelly and Big Salmon Mountains approximately between river miles 1,300 and 1,800. Chinook salmon stocks within these geographic regions have been termed runs (McBride and Marshall 1983) and defined as the lower, middle, and upper Yukon runs, respectively.

The purpose of this report is to allocate the 1983 Yukon River commercial and subsistence harvest of chinook salmon by run of origin. Commercial catches from Districts 1, 2, and 3 were allocated to run of origin by analysis of scale patterns of age 6_2 and 5_2 fish[1], and catch and escapement age composition data. Estimates of the contribution by run in commercial catches were applied to subsistence catches from these districts. Commercial and subsistence catches from Districts 5 and 6, and the Yukon Territory were allocated based on geography.

METHODS

In this report, we build upon the catch, escapement, and age composition data base compiled by Buklis and Wilcock (1984) for the 1983 return of salmon to the Yukon River.

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[1] Gilbert-Rich formula: the first numeral refers to the total age of the fish. The second numeral, usually subscripted, refers to the number of years of freshwater residence. Marine age is the arithmetic difference between these two numbers.

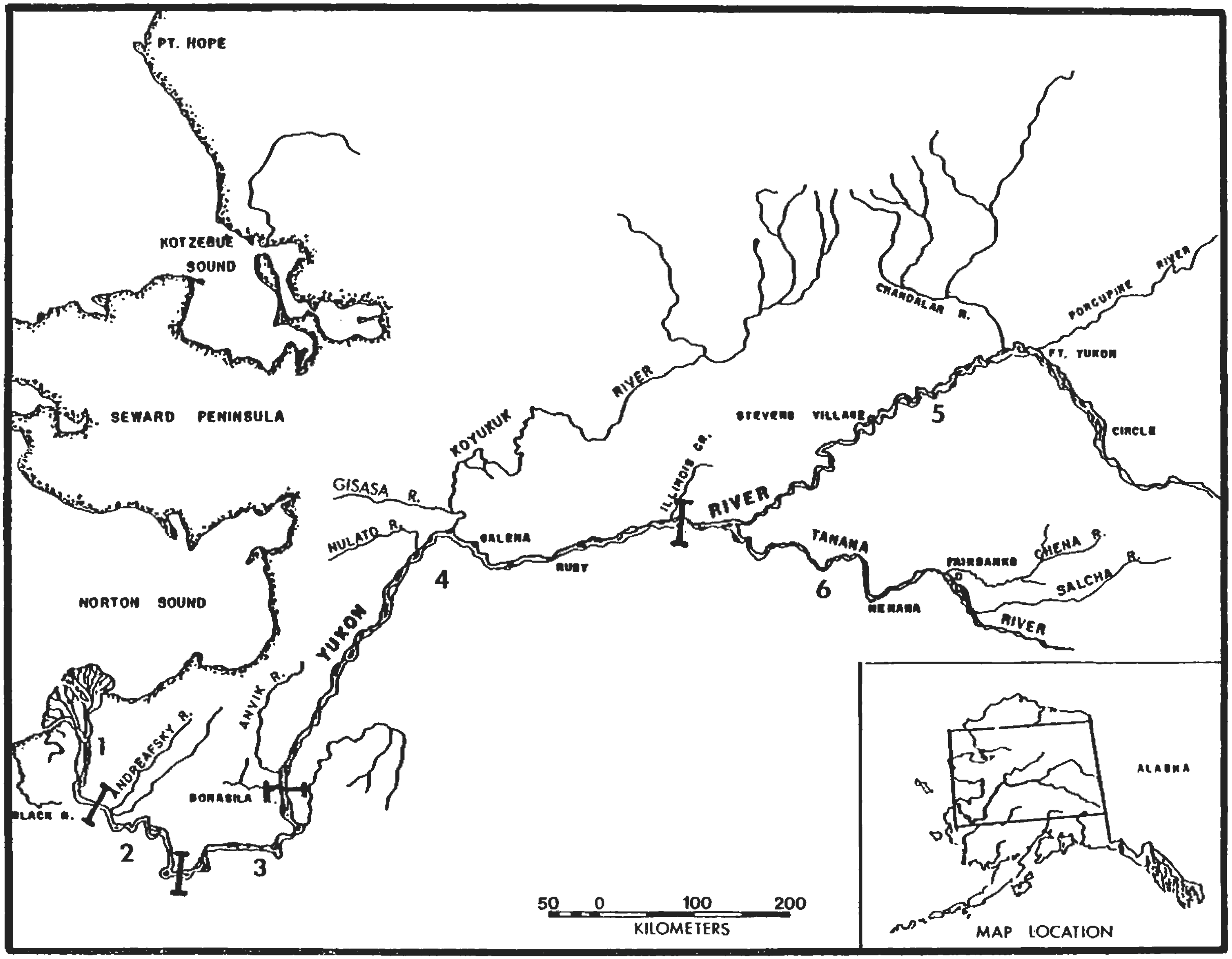

Figure 1. Alaskan portion of the Yukon River showing the six regulatory districts.

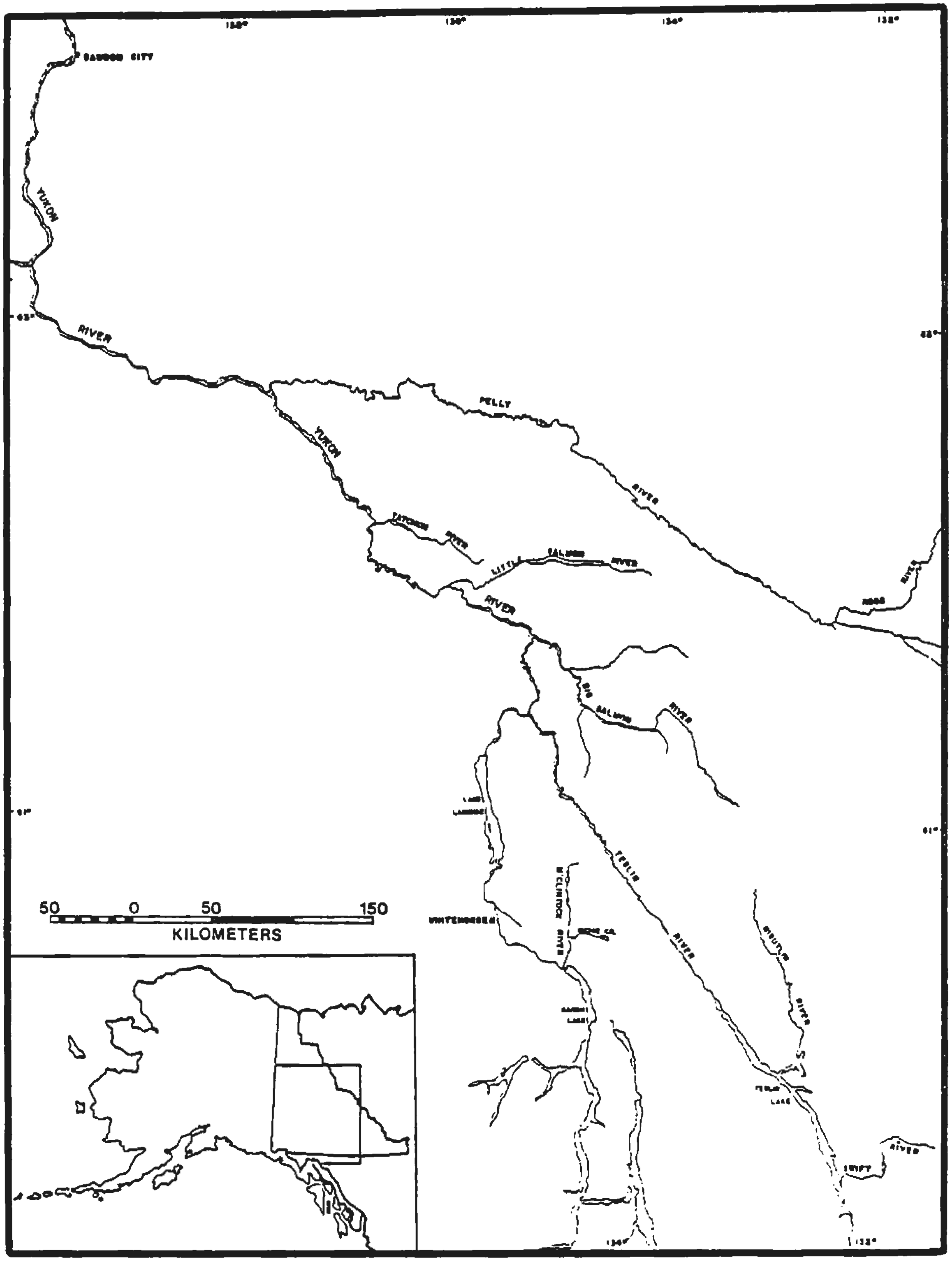

Figure 2. Canadian portion of the Yukon River.

Age Composition

Scale samples provided age information of fish in the catch and escapement. Samples were collected on the left side of the fish approximately two rows above the lateral line and on the diagonal row downward from the posterior insertion of the dorsal fin (Clutter and Whitesel 1956). Scales were mounted on gummed cards and impressions were made in cellulose acetate.

Catch:

Scales were collected[1] from the commercial catches from Districts 1, 2, and 3, and the Yukon Territory and an age composition was estimated for each fishery (Buklis and Wilcock 1984). Although subsistence catches in these districts were not sampled, subsistence fishing occurred concurrently with commercial effort and the age composition for subsistence catches in each district was assumed to be similar to the commercial catch composition.

Samples were also collected from District 5 commercial and subsistence catches and a combined age composition was estimated for these fisheries. Catches in Districts 4 and 6 were not adequately sampled to estimate the age composition.

Escapement:

Scale samples were collected during peak spawner die off from the major spawning tributaries (as determined by aerial surveys). Virtually all samples were collected from carcasses. The age composition of the middle and upper Yukon areas was estimated by weighting the age composition estimated for the individual spawning tributaries in each area by the escapement to each tributary as measured by aerial surveys. There were no aerial survey data for the Andreafsky River in 1983 and only data from a poor survey of the Anvik River was available. Therefore, a pooled sample was selected for the lower Yukon run weighted for abundance of individual stocks using sonar data from the Andreafsky River and the limited aerial survey data for the Anvik River.

Catch Apportionment

Linear discriminant function analysis (LDF) of scale pattern data and observed differences in age composition between escapements were used to allocate 1983 Yukon River chinook salmon catches to run of origin.

Scale Pattern Analysis:

Because many of the scale characters used in previous analyses were not normally distributed (violating a basic assumption of LDF), nearest neighbor analysis

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[1] Sampling of Alaskan fisheries was conducted by Alaska Department of Fish and Game staff, Division of Commercial Fisheries. Sampling of Canadian fisheries was conducted by Canadian Department of Fisheries and Oceans staff.

(Clover and Hart 1967) was used to identify the origin of Yukon River chinook salmon by McBride and Marshall (1983), and Wilcock and McBride (1983). For the 1983 analysis, new scale characters with distributions which were approximately normal were calculated, and linear discriminant function analysis (Fisher 1936) of scale pattern data was investigated by comparing it to nearest neighbor analysis (Appendix A). Although univariate normality does not ensure normality in the multivariate case, the LDF has been shown to be robust to violations of this assumption (Krzanowski 1977). Results were similar for the two methods of analysis and linear discriminant function analysis of scale patterns was used to classify 1983 catches to run of origin rather than the more costly nearest neighbor analysis.

Escapement samples provided scales of known origin that were used to build the discriminant functions. Commercial catch and test fish[1] samples provided scales of unknown origin which were classified using the discriminant functions to estimate the proportions of lower, middle, and upper Yukon age 6_2 and 5_2 fish in the District 1 and 2 catches, and age 6_2 fish in the District 3 catch.

Measurements of scale features were made as described by McBride and Marshall (1983). Scale images were projected at 100x magnification using equipment similar to that described by Ryan and Christie (1976) and measurements were made and recorded by a microcomputer-controlled digitizing system. Measurements were taken along an axis approximately perpendicular to the sculptured field and the distance between each circulus in each of three scale pattern zones (Figure 3) was recorded. The three zones were: (1) scale focus to the outside edge of the freshwater annulus (first freshwater annular zone), (2) outside edge of the freshwater annulus to the last circulus of the freshwater growth (freshwater plus growth zone), and (3) the last circulus of the freshwater growth zone to the outer edge of the first ocean annulus (first marine annular zone). In addition, the incremental distance of successive scale pattern zones was also measured for: (1) the last circulus of the first ocean annulus to the last circulus of the second ocean annulus (age 5_2 and age 6_2), and (2) the last circulus of the second ocean annulus to the last circulus of the third ocean annulus (age 6_2 only). Eighty scale characters (Appendix Table B1) were calculated from the basic incremental distances and circuli counts.

Scale samples (standards) representing the three Yukon chinook salmon runs were constructed for the 6_2 and 5_2 age classes. Because of limited sample sizes, all available samples representing the lower Yukon (the Andreafsky and Anvik Rivers) were used. Scales representing the middle Yukon run were selected in approximately equal numbers (as indicated by aerial surveys) from the Chena and Salcha Rivers. Scales representing the upper Yukon run were chosen at random from the Yukon Territory commercial catch samples. I felt that the Yukon Territory sample provided

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[1] ADF&G conducts test fishing projects in the Yukon River delta to index the timing and magnitude of the salmon migration entering the Yukon River. Test fishing is conducted concurrently with the commercial fishery and samples collected from these projects also represent fish of unknown origin in District 1.

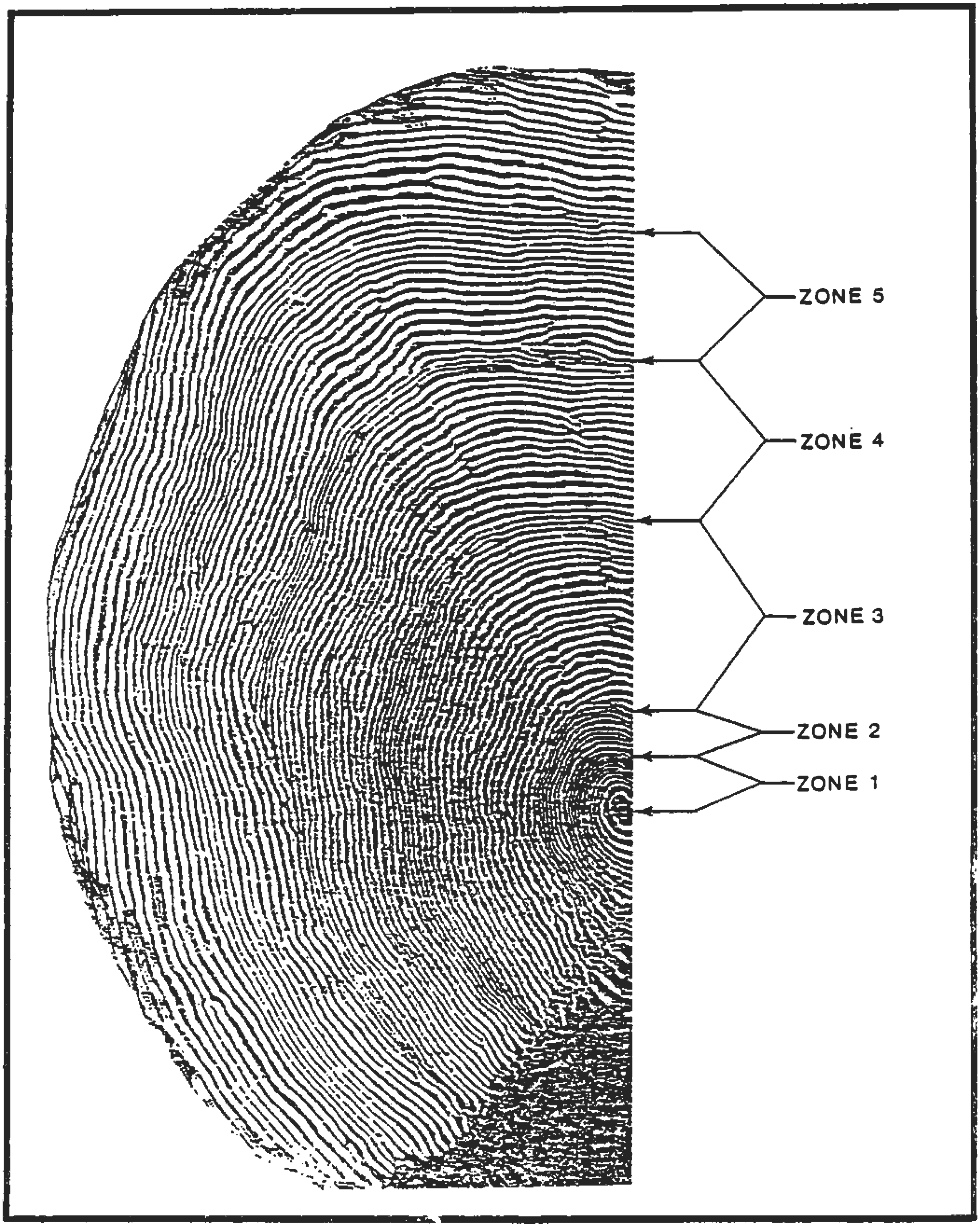

Figure 3. Age 6_2 chinook salmon scale showing the zones measured for the linear discriminant analysis.

a more representative composite of the overall upper Yukon escapement than did samples from individual spawning streams.

Linear discriminant functions were calculated for each age class. Selection of scale characters for each analysis was by a forward stepping procedure using partial F statistics as the criteria for entry/deletion of variables (Enslein et al. 1977). A nearly unbiased estimate of classification for each LDF was determined using a leaving-one-out procedure[1] (Lachenbruch 1967).

Contribution rates for age 6_2 fish in the Districts 1 and 2 catches were estimated for each fishing period during the chinook salmon season and a pooled sample for the chum salmon *(O. keta)* season[2]. A single contribution rate for age 6_2 fish in the District 3 catch was estimated from a sample collected during the second fishing period. Because of limited samples, contribution rates of age 5_2 fish in Districts 1 and 2 were computed for pooled fishing periods. Point estimates were adjusted for misclassification errors using the procedure of Cook and Lord (1978). The variance and 90% confidence intervals for these estimates were computed using the procedures of Pella and Robertson (1979).

A catch sample was reclassified with a model representing only two runs if the final proportional estimate was less than or equal to zero for the run in question. A two-way model was constructed using only standards from the two runs with positive classification estimates. Data were resubmitted to the variable selection routines and a new subset of variables was chosen for inclusion in the two-way model.

Differential Age Composition Analysis:

Allocation of the remaining age classes in the Districts 1, 2, and 3 commercial catches was based on differences in escapement age composition in each of the three runs. Escapement age composition data were directly compared by computing ratios

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[1] The leaving-one-out procedure estimates classification accuracy for a standard with n fish by: (1) selecting one fish for which discriminant functions are calculated from the remaining n-1 scales, (2) assigning the selected scale to a group with the discriminant functions, and (3) repeating the procedure n times with a different scale selected each time. Classification accuracy is the percentage of fish assigned to the correct run or origin.

[2] Most of the chinook salmon harvested in these two districts are taken in a directed fishery that commences in early June when mostly gillnets of 203 to 229 mm (8 to 9 inch) stretched mesh are operated. This June fishery is commonly referred to as the "early" or "chinook" season. During this fishery, there are no gillnet mesh size restrictions and most fishermen operate large mesh nets for chinook salmon. However, some nets of 140 to 152 mm (5-1/2 - 6 inch) stretched mesh are operated, also. The remaining harvest is taken incidentally to the chum *(O. keta)* and coho *(O. kisutch)* salmon fishery. This fishery, in which gillnets of up to 152 mm (6 inch) stretched mesh are allowed, commences in late June to early July.

for each run whereby the proportion in the escapement of the age class in question was divided by the proportion in the escapement of an age class of known catch composition estimated by scale pattern analysis (either age 5_2 or 6_2):

E_{ci} = Proportion of fish of age class i in run c escapement samples where i is an age class of unknown run composition in the catch.

E_{ca} = Proportion of fish of age class a in run c where a is an age class of known run composition in the catch (either age 5_2 or 6_2).

$R_{ci} = E_{ci}/E_{ca}$

Because the relative contribution of age 4_2 fish decreased in escapement samples moving progressively upriver, this age class was compared to age 5_2 fish. All other age classes (6_3, 7_2, 7_3, and 8_3) were compared to age 6_2 fish since the relative contributions of all of these age classes increased in escapement samples moving progressively upriver.

These ratios of proportional abundance were then multiplied by the allocated catch of either age 5_2 or 6_2 fish. These computations were summed over all runs to calculate age-specific contribution rates. Multiplication by total catch by age class yields age-specific run contribution estimates:

N_i = Total catch of age group i.

N_{ca} = Catch of age group a (where a is either age 6_2 or 5_2) in run c.

F_{ci} = Proportion of fish of run c in N_i.

$$F_{ci} = \frac{R_{ci} \cdot N_{ca}}{\sum_{j=i}^{3} R_{ji} \cdot N_{ja}}$$ (where j is run number: either 1, 2 or 3 for lower, middle or upper run).

The total harvest of run c for age group i is then:

$$N_{ci} = F_{ci} \cdot N_i$$

Estimates of run composition from scale pattern analysis and differential age composition analysis of Districts 1, 2, and 3 commercial catches were used to allocate the catches of subsistence fisheries in these districts. Catches from District 4 were not adequately sampled and therefore were not allocated by run of origin.

Catches in Districts 5 and 6, and the Yukon Territory were allocated to run based on geography. The entire District 5 harvest was allocated to the upper Yukon run as most of the District 5 catch occurred above the confluence of the Tanana River and there are few documented spawning concentrations between the Tanana River confluence and the Yukon Territory fishery centered in Dawson. The entire District 6 harvest was allocated to the middle Yukon run although no attempt was made to apportion catches by age class.

RESULTS AND DISCUSSION

Age Composition

Trends in age composition for the lower, middle, and upper Yukon River escapements (Table 1) were consistent with previous years' results (McBride and Marshall 1983, Wilcock and McBride 1983). The proportion of older fish increased in spawning populations moving progressively upriver. Age 6_2 fish were predominant in all escapements and increased in relative abundance from the lower, and middle, to the upper Yukon (45.9%, and 55.3%, to 68.4%, respectively). Conversely, the proportion of younger fish (ages 4_2 and 5_2 combined) declined in escapements moving upriver (53.4% lower, 40.3% middle, and 18.1% upper river fish). Nearly all 2-freshwater age fish were observed in the upper Yukon escapement (combined age 6_3, 7_3, and 8_3 total of 6.7%).

Catch Apportionment

The catch was apportioned into geographic region or origin by scale pattern analysis and by differential age composition analysis. Utilizing both of these methods, the total run of the commercial and subsistence harvests were allocated to run of origin.

Scale Pattern Analysis:

Scale characters from the zone of freshwater plus growth were the most powerful in distinguishing the three runs. Secondarily selected variables were generally derived from measurements of the initial portion of the first marine annular zone and the initial portion of the first freshwater annular zone. The number of circuli and the width of the freshwater plus growth zone increased markedly from the lower to upper Yukon runs (Appendix Table B2). Conversely, number of circuli and width of the first freshwater and first marine annular zones generally decreased from the lower to upper runs.

Average classification accuracies of the three-way models for age 6_2 and 5_2 fish (Tables 2 and 3) were similar (69.4% and 64.8%, respectively). Lower Yukon fish had the highest classification accuracies in both models (75.6% and 72.0%, respectively). Misclassification rates between middle and upper Yukon fish were large (range of 18.9% to 27.7%).

Contribution rates for the three runs were variable (Tables 4 and 5). Middle and upper Yukon fish were generally predominant in age 6_2 catches while lower and middle Yukon fish were generally predominant in age 5_2 catches. Demonstrable differences over time by run were generally not evident for age 6_2 fish (Figure 4). However, the estimates for lower Yukon fish tended to increase over time. Point estimates for upper Yukon fish peaked during period 3 in both Districts 1 and 2. Demonstrable differences over time by run were evident for age 5_2 lower Yukon fish (Figure 5). The contribution of lower Yukon fish increased from pooled periods 1-2 to pooled periods 5-17 (chum salmon season) in both districts. Point estimates for upper Yukon fish tended to decline over the duration of the fisheries in both districts.

Table 1. Age composition summary of chinook salmon escapements, Yukon River, 1983.

Location	N	Escapement Estimates[1]	Age Group 3_2	4_2	5_2	6_2	6_3	7_2	7_3	8_3
Lower										
Andreafsky R.	355[2]	2,720[3]		15.2	38.0	46.2	0.3	0.3		
Anvik R.	306[4]	653[5]	0.3	18.1	36.0	44.8	1.0			
Total	661	3,373	0.1	15.7	37.6	45.9	0.4	0.2	0.0	0.0
Middle										
Chena R.	395	2,487		22.0	20.0	53.7		4.8		
Salcha R.	451	1,961		16.6	21.5	58.1		3.6	0.2	
Total	846	4,448	0.0	19.7	20.7	55.3	0.0	4.3	0.1	0.0
Upper										
Big Salmon	199	640[6]		0.5	11.6	70.4		17.1		0.5
Little Salmon R.	117	101		6.8	16.2	70.1		6.0	0.9	
Nisutlin R.	189	1,015[6]		0.5	14.3	72.5	1.7	1.6	10.1	
Michie Cr.	30	40[7]		3.3	13.3	33.3	13.3	0.0	36.7	
Tatchun Cr.	53	264			43.4	52.8		3.8		
Total	588	2,060	0.0	0.8	17.3	68.4	0.8	6.9	5.7	0.2

1 Aerial surveys, except as noted.

2 Carcass samples = 252. Beach seine samples = 103.

3 Sonar estimate.

4 Carcass samples = 302. Beach seine samples = 4.

5 Poor survey due to inclement weather.

6 Foot survey, Department of Fisheries and Oceans, Canada.

7 Whitehorse fishway count = 905.

Table 2. Classification accuracies of the linear discriminant model for age 6_2 Yukon River chinook salmon.

Actual Region of Origin	Sample Size	Classified Region of Origin: Lower	Middle	Upper
Lower	209	.756	.201	.043
Middle	307	.107	.635	.257
Upper	224	.054	.254	.692

Average Correctly Classified = .694

Actual Region of Origin	Sample Size	Classified Region of Origin: Middle	Upper
Middle	307	.707	.293
Upper	224	.308	.692

Average Correctly Classified = .700

Table 3. Classification accuracies of the linear discriminant model for age 5_2 Yukon River chinook salmon.

Actual Region of Origin	Sample Size	Classified Region of Origin: Lower	Middle	Upper
Lower	132	.720	.129	.152
Middle	127	.142	.669	.189
Upper	130	.169	.277	.554

Average Correctly Classified = .648

Actual Region of Origin	Sample Size	Classified Region of Origin: Lower	Middle
Lower	127	.787	.213
Middle	126	.111	.889

Average Correctly Classified = .838

Table 4. Run composition estimates for age 6_2 chinook salmon from the commercial catches in Districts 1, 2, and 3.

District	Commercial Fishing Period	Dates	N	Region of Origin	Proportion of Catch	90 Percent Confidence Interval Lower Bound	90 Percent Confidence Interval Upper Bound
1	Preseason[1]	5/29-6/6	100	Lower	tr		
				Middle	0.707	0.487	0.926
				Upper	0.293	0.074	0.513
	1	6/9-6/10	99	Lower	0.091	-0.028	0.212
				Middle	0.433	0.143	0.722
				Upper	0.476	0.218	0.734
	2	6/13-6/14	100	Lower	0.016	-0.081	0.113
				Middle	0.280	-0.011	0.572
				Upper	0.704	0.436	0.973
	3	6/16-6/17	100	Lower	tr		
				Middle	0.331	0.106	0.555
				Upper	0.669	0.445	0.894
	4	6/20-6/21	102	Lower	0.218	0.079	0.358
				Middle	0.341	0.065	0.617
				Upper	0.441	0.199	0.682
	5-6[2]	6/23-6/28	96	Lower	0.231	0.084	0.380
				Middle	0.432	0.146	0.718
				Upper	0.337	0.094	0.580
	7-17[2]	6/31-8/12	100	Lower	0.395	0.231	0.558
				Middle	0.359	0.086	0.632
				Upper	0.246	0.030	0.464
2	1	6/12-6/13	99	Lower	0.012	-0.090	0.116
				Middle	0.528	0.232	0.824
				Upper	0.460	0.194	0.726
	2	6/15-6/16	99	Lower	0.018	-0.090	0.128
				Middle	0.635	0.337	0.932
				Upper	0.347	0.084	0.610
	3	6/19-6/20	89	Lower	tr		
				Middle	tr		
				Upper	1.000		
	4	6/22-6/23	96	Lower	0.150	0.014	0.287
				Middle	0.530	0.237	0.822
				Upper	0.320	0.070	0.572
	5[2]	6/26-6/27	63	Lower	0.282	0.096	0.469
				Middle	0.331	-0.009	0.670
				Upper	0.387	0.096	0.678
3	2	6/20-6/21	90	Lower	tr		
				Middle	0.203	-0.033	0.439
				Upper	0.797	0.561	1.033

[1] Prior to commercial season. All samples obtained from test fish catches.

[2] Chum season.

tr = Trace

Table 5. Run composition estimates for age 5_2 chinook salmon from the commercial catches in Districts 1, 2, and 3.

District	Commercial Fishing Periods	Dates	N	Region of Origin	Proportion of Catch	90 Percent Confidence Interval Upper Bound	Lower Bound
1	1-2	6/9-6/14	97[2]	Lower	0.135	-0.046	0.315
				Middle	0.607	0.316	0.897
				Upper	0.258	-0.038	0.555
	3-4	6/16-6/21	63[3]	Lower	0.382	0.137	0.627
				Middle	0.532	0.210	0.852
				Upper	0.086	-0.231	0.404
	5-6[1]	6/23-6/28	90[4]	Lower	0.444	0.306	0.581
				Middle	0.556	0.419	0.694
				Upper	tr		
	7-17[1]	6/31-8/12	76[5]	Lower	0.614	0.463	0.766
				Middle	0.386	0.234	0.537
				Upper	tr		
2	1-2	6/12-6/16	88	Lower	0.184	-0.013	0.382
				Middle	0.754	0.451	1.058
				Upper	0.062	-0.231	0.354
	3-4	6/19-6/23	65	Lower	0.233	0.003	0.463
				Middle	0.755	0.418	1.092
				Upper	0.012	-0.306	0.330
	5-17[1]	6/26-8/14	42	Lower	0.666	0.467	0.865
				Middle	0.334	0.135	0.533
				Upper	tr		

[1] Fall chum salmon.

[2] Includes 49 test fishing samples.

[3] Includes 2 test fishing samples.

[4] Includes 11 test fishing samples.

[5] Includes 12 test fishing samples.

tr = Trace

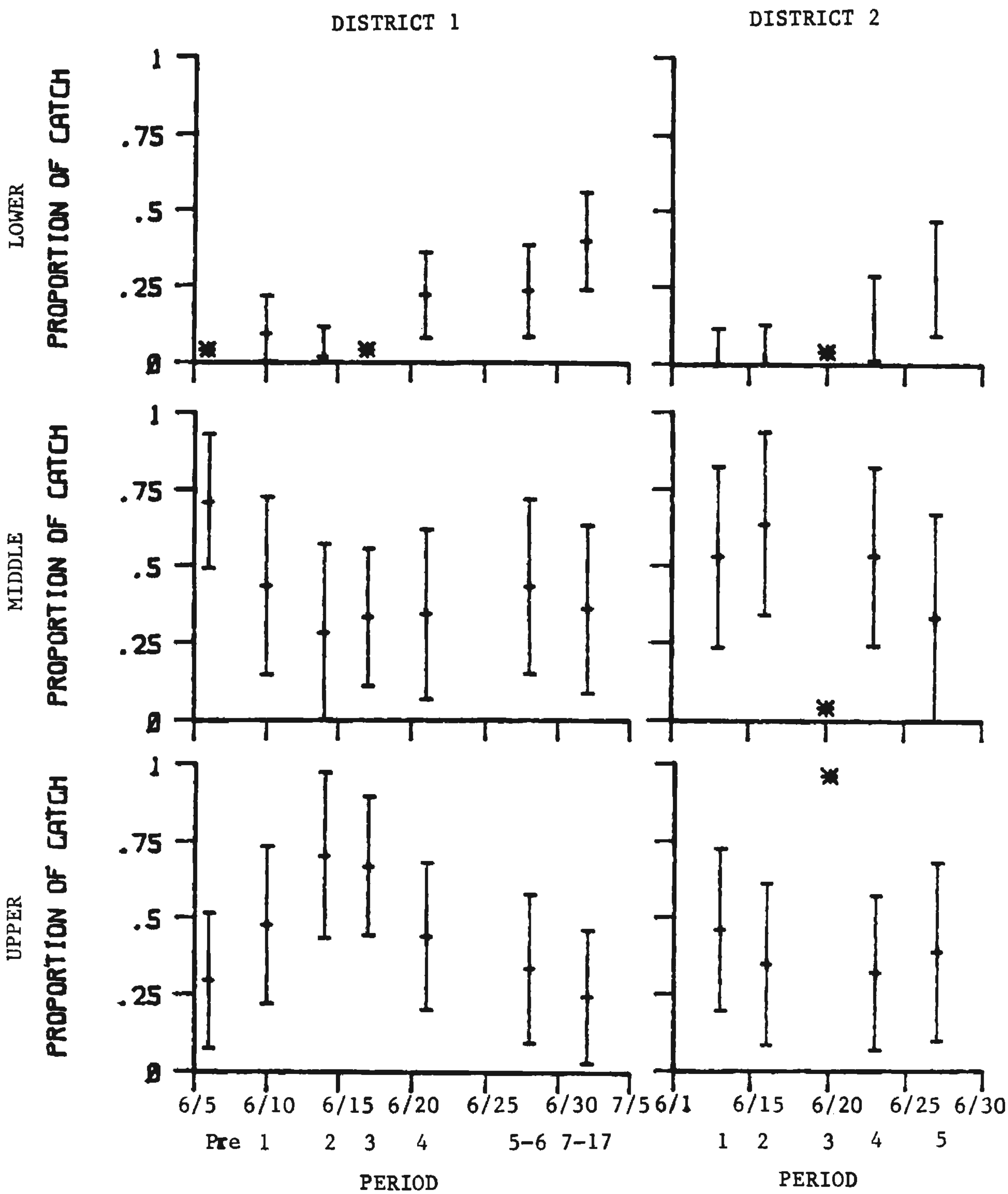

Figure 4. Run composition estimates and 90% confidence intervals from the scale pattern analysis of age 6_2 chinook salmon, Districts 1 and 2, Yukon River. Asterisk represents estimates less than zero or greater than one.

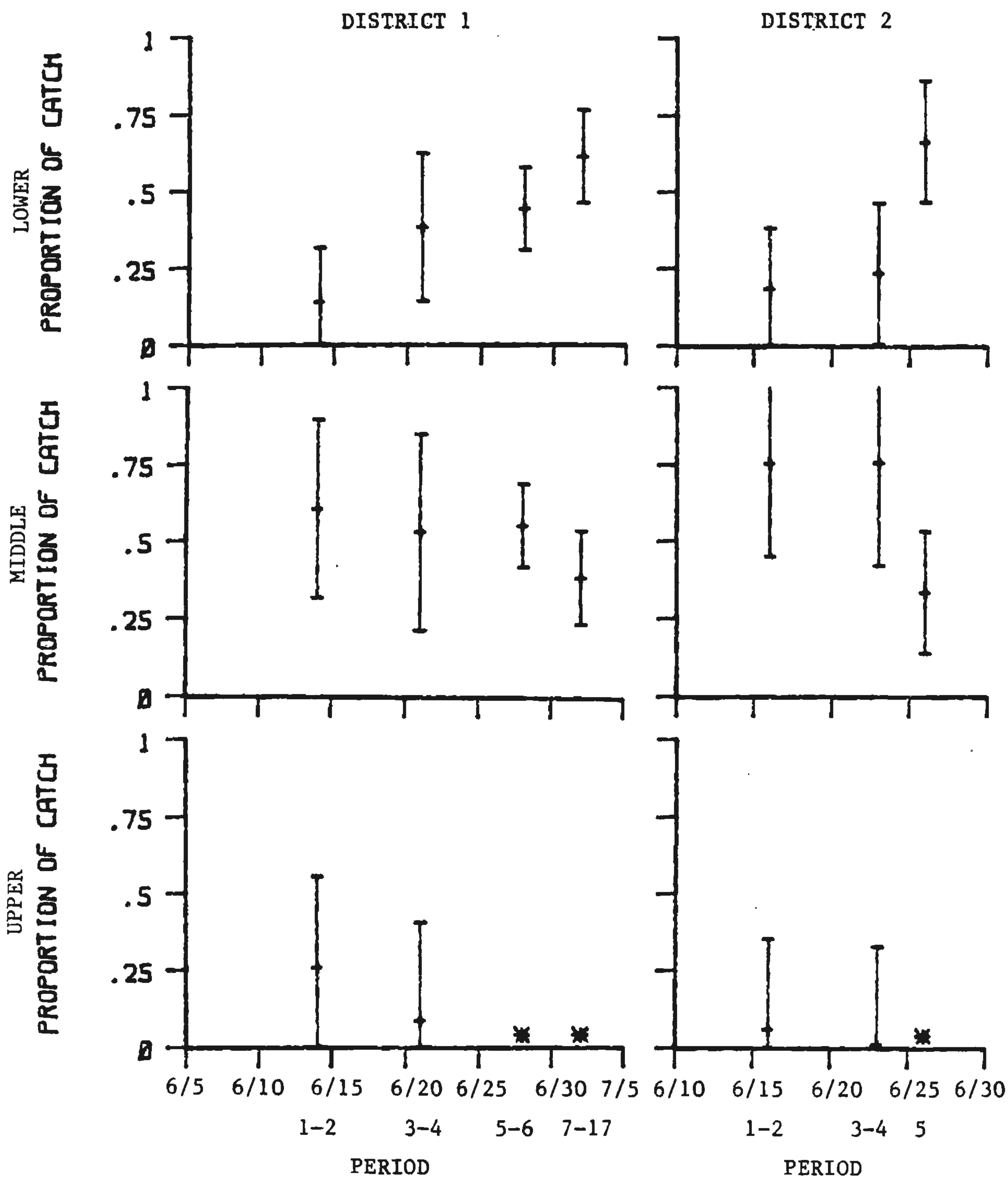

Figure 5. Run composition estimates and 90% confidence intervals from the scale pattern analysis of age 5_2 chinook salmon, Districts 1 and 2, Yukon River. Asterisk represents estimates less than zero or greater than one.

Most of the age 6_2 catch in District 1 (Table 6) was of upper Yukon origin (33,289 fish or 54.7%). Upper Yukon fish were most abundant for every period except the chum salmon season. Catches of lower Yukon fish were low (5,762 fish or 9.5%) and catches of middle Yukon fish (21,810 fish or 35.8%) were generally intermediate.

Fish of upper Yukon origin also dominated the age 6_2 catch in District 2 and totaled 14,022 fish (55.2%). Unlike District 1, however, middle Yukon fish were most abundant for every period except period 3, for which all fish (7,205) were allocated to the upper Yukon run. We assume that lower and middle Yukon fish were actually present in low levels of abundance during this period.

Age 5_2 catches were comprised primarily of middle Yukon fish (Table 7). The District 1 harvest of age 5_2 fish was comprised of 53.5% (9,765 fish) middle Yukon, 35.4% (6,461 fish) lower Yukon, and 11.1% (2,021 fish) upper Yukon fish.

Middle Yukon fish also dominated the catch of age 5_2 fish in District 2 (6,486 fish or 59.5%). Lower Yukon fish comprised 38.5% (4,194) fish of the catch while few fish (226 fish or 2.1%) were allocated to the upper Yukon run.

Differential Age Composition Analysis:

Large variations were observed in the contribution rates for the remaining age classes (Table 8). The major portion of the age 4_2 harvests in Districts 1 and 2 (4,823 fish or 77.1%, and 3,190 fish or 78.0%, respectively) were allocated to the middle Yukon run. Upper Yukon fish comprised virtually all of the age 6_3, 7_2, 7_3, and 8_3 catches.

Overall, commercial catches were composed of nearly equal numbers of middle and upper Yukon fish in both Districts 1 (38,655 fish or 40.5% and 43,101 fish or 45.2%, respectively) and District 2 (19,744 fish or 45.6% and 16,166 fish or 37.4%, respectively). Lower Yukon fish were least abundant to both Districts 1 and 2 (13,701 fish or 14.4%, and 7,319 fish or 16.9%, respectively).

Total Harvest:

Based on the findings of the scale pattern analysis of age 6_2 and 5_2 fish and the differential age composition allocation of the remaining age classes, the commercial and subsistence fishery catches of chinook salmon from all districts of the Yukon River drainage except District 4 were allocated to run of origin (Table 8). Most of the total harvest (excluding District 4) was composed of upper Yukon River fish (105,565 fish or 51.4%). Middle Yukon fish were next in abundance at 74,859 fish (36.4%). The total contribution of 25,036 from the lower Yukon run comprised only 12.2% of the total harvest. Total harvest values include catches documented in Canada.

ACKNOWLEDGMENTS

The author is grateful to the Division of Commercial Fisheries Yukon area staff for providing assistance in gathering the samples, particularly members of the Emmonak field office crews; James Brady, Helen Hamner, Kevin Grubbs, Janice Gabrielli, Dave Rhode, and Steve Brooks. Appreciation is given to Mike Geiger

Table 6. Allocation of age 6_2 chinook salmon by run for the commercial fishery in Districts 1 and 2 by fishing period.

Fishing Period	Region of Origin	District 1 Dates	District 1 No. of Fish	District 2 Dates	District 2 No. of Fish
1	Lower	6/9-6/10	1,349	6/12-6/13	46
	Middle		6,408		2,009
	Alaska Total		7,757		2,055
	Upper		7,045		1,750
	Total		14,802		3,805
2	Lower	6/13-6/14	136	6/15-6/16	89
	Middle		2,385		3,151
	Alaska Total		2,521		3,240
	Upper		5,996		1,721
	Total		8,517		4,961
3	Lower	6/16-6/17	tr	6/19-6/20	tr
	Middle		7,000		tr
	Alaska Total		7,000		tr
	Upper		14,149		7,205
	Total		21,149		7,205
4	Lower	6/20-6/21	1,907	6/22-6/23	664
	Middle		2,983		2,345
	Alaska Total		4,890		3,009
	Upper		3,858		1,416
	Total		8,748		4,425
5-6[1]	Lower	6/23-6/28	914	6/26-8/14[2]	1,406
	Middle		1,710		1,650
	Alaska Total		2,624		3,056
	Upper		1,334		1,930
	Total		3,958		4,986
7-17[1]	Lower	6/31-8/12	1,456		
	Middle		1,324		
	Alaska Total		2,780		
	Upper		907		
	Total		3,687		
Season Total	Lower	6/9-8/12	5,762	6/12-8/14	2,205
	Middle		21,810		9,155
	Alaska Total		27,572		11,360
	Upper		33,289		14,022
	Total		60,861		25,382

[1] Fall chum season.

[2] Periods 5-17. Allocation based on period 5 sample only.

tr = Trace

Table 7. Allocation of age 5_2 chinook salmon by run for the commercial fishery in Districts 1 and 2 by fishing period.

Fishing Period	Region of Origin	District 1 Dates	District 1 No. of Fish	District 2 Dates	District 2 No. of Fish
1-2	Lower	6/9-6/14	774	6/12-6/16	532
	Middle		3,484		2,179
	Alaska Total		4,258		2,711
	Upper		1,481		179
	Total		5,739		2,890
3-4	Lower	6/16-6/21	2,399	6/19-6/23	902
	Middle		3,340		2,923
	Alaska Total		5,739		3,825
	Upper		540		47
	Total		6,279		3,872
5-6[1]	Lower	6/23-6/28	1,402	6/28-8/14[2]	2,760
	Middle		1,755		1,384
	Alaska Total		3,157		4,144
	Upper		tr		tr
	Total		3,157		4,144
7-17[1]	Lower	6/30-8/12	1,886		
	Middle		1,186		
	Alaska Total		3,072		
	Upper		tr		
	Total		3,072		
Season Total	Lower	6/9-8/12	6,461	6/12-8/14	4,194
	Middle		9,765		6,486
	Alaska Total		16,226		10,680
	Upper		2,021		226
	Total		18,247		10,906

[1] Fall chum season.

[2] Periods 5-17. Allocation based on period 5 sample only.

tr = Trace

Table 8. Estimated region of origin by age class of chinook salmon from Districts 1, 2, 3, 5, 6, and Yukon Territory commercial and subsistence catches, Yukon River[1].

District	Fishery	Dates	Region of Origin	Number of Fish by Age Class 42	52	53	62	63	72	73	83	Total
1	Commercial Gillnet	6/9-8/12	Lower	1,382	6,461		5,762	27	69			13,701
			Middle	4,823	9,765		21,810		2,216	41		38,655
			Alaska Total	6,205	16,226		27,572	27	2,285	41		52,356
			Upper	50	2,021		33,289	350	4,420	2,879	92	43,101
			Total	6,255	18,247		60,861	377	6,705	2,920	92	95,457
	Subsistence[1] Gillnet		Lower	91	424		378	2	5			900
			Middle	316	641		1,431		145	3		2,536
			Alaska Total	407	1,065		1,809	2	150	3		3,436
			Upper	3	133		2,184	22	290	189	6	2,827
			Total	410	1,198		3,993	24	440	192	6	6,263
2	Commercial Gillnet	6/12-8/14	Lower	894	4,194		2,205		26			7,319
			Middle	3,190	6,486		9,155		912	1		19,744
			Alaska Total	4,084	10,680		11,360		938	1		27,063
			Upper	6	226		14,022		1,824	88		16,166
			Total	4,090	10,906		25,382		2,762	89		43,229
	Subsistence[3] Gillnet		Lower	103	806		502		7			1,418
			Middle	366	1,247		2,087		228			3,928
			Alaska Total	469	2,053		2,589		235			5,346
			Upper	1	44		3,194		456	24		3,719
			Total	470	2,097		5,783		691	24		9,065
3	Commercial[4] Gillnet	6/16-8/16	Lower	6	97		665	2	4			774
			Middle	21	150		2,609		124			2,904
			Alaska Total	27	247		3,274	2	128			3,678
			Upper		102		tr	25	248	53		428
			Total	27	349		3,274	27	376	53		4,106
	Subsistence[5] Gillnet		Lower	7	116		795	2	4			924
			Middle	24	180		3,120		149	1		3,474
			Alaska Total	31	296		3,915	2	153	1		4,398
			Upper	1	121		tr	30	297	63		512
			Total	32	417		3,915	32	450	64		4,910
5	[6]	6/24-7/31	Upper	1,902	7,164	44	10,038	221	840	176		20,385
6	[6] [7]	6/27-8/7	Middle									3,617
Yukon Territory	Commercial Gillnet	7/3-9/4	Upper	145	1,408		9,238	41	1,760	435		13,027
	Subsistence[8] Gillnet		Upper	60	584		3,829	17	730	180		5,400
Total			Lower	2,483	12,098		10,307	33	115			25,036
			Middle	8,741	18,469		40,212		3,774	46		74,859
			Alaska Total	11,224	30,567		50,519	33	3,889	46		99,895
			Upper	2,168	11,803	44	75,794	706	10,865	4,087	98	105,565
			Total	13,391	42,370	44	126,313	739	14,754	4,133	98	205,460[9]

[1] District 4 commercial and subsistence catches not apportioned due to insufficient samples.
[2] Allocation based on season total District 1 commercial catch samples.
[3] Allocation based on season total District 2 commercial catch samples.
[4] Age 6_2 allocation based on scale pattern analysis of commercial catch sample collected on 6/21. Remaining age classes based on District 2 commercial catch.
[5] Allocation based on District 3 commercial catch allocation estimate.
[6] Combined fishwheel and gillnet.
[7] Not apportioned by age class due to insufficient samples.
[8] Age apportionment based on Yukon Territory commercial catch samples.
[9] [illegible] l catch including District 4 commercial and sub[illegible]ence harvests = 215,815.

and Fred Andersen for their support and for providing the basic catch and escapement data. The author is also grateful to the Statewide Stock Biology Group staff for their advice and assistance in the data collection and analysis, including Bev Cross, Bob Conrad, and Bill Goshert. Particular thanks are due to Doug McBride for his continued guidance and editorial support. Critical review was provided by Bob Conrad and Linda Brannian.

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APPENDIX A

Classification accuracies and comparative run composition estimates for evaluation of nearest neighbor and linear discriminant function analyses

Appendix Table A1. Classification accuracies, sample sizes, and variables selected for nearest neighbor analysis of age 6_2 chinook salmon, Yukon River.

Actual Group of Origin	Sample Size	Classied Group of Origin		
		Lower	Middle	Upper
Lower	200	.755	.180	.065
Middle	200	.125	.660	.215
Upper	200	.075	.295	.630

Average Correctly Classified = .682

Variables Used:
1 - incremental distance, freshwater plus-growth
2 - incremental distance of last 4 circuli, freshwater plus-growth zone
3 - incremental distance first 6 circuli, first freshwater zone
4 - incremental distance between the third and twelfth circuli, first marine zone

Appendix Table A2. Classification accuracies, sample sizes, and variables selected for linear discriminant function analysis for age 6_2 chinook salmon, Yukon River.

Actual Group of Origin	Sample Size	Classified Group of Origin: Lower	Middle	Upper
Lower	209	.756	.201	.043
Middle	307	.107	.635	.257
Upper	224	.054	.254	.692

Average Correctly Classified = .694

Variables Used:
1 - Incremental distance of first freshwater annular zone relative to entire freshwater growth
2 - Incremental distance from third to twelfth circuli, first marine zone
3 - Incremental distance first 6 circuli, first freshwater growth zone
4 - Incremental distance of third through twelfth circulus of first marine zone relative to size of zone
5 - Number circuli in first 3/4 of first freshwater zone
6 - Incremental distance of freshwater plus-growth
7 - Incremental distance of first 2 circuli in first freshwater zone relative to size of zone
8 - Average incremental distance between circuli of first marine zone
9 - Number of circuli in first half of first marine growth zone

Appendix Table A3. Comparison of adjusted proportional estimates and 90% confidence intervals for various hypothetical proportions of lower, middle, and upper Yukon River chinook salmon using nearest neighbor and linear discriminant function analyses.

		Nearest Neighbor		Linear Discriminant	
Group of Origin	Test Proportion	Adjusted Estimate	90% Confidence Interval	Adjusted Estimate	90% Confidence Interval
Lower	.10	.035	± .114	.056	± .104
Middle	.30	.031	± .311	.132	± .286
Upper	.60	.934	± .297	.812	± .267
Lower	.10	-.023	± .123	.003	± .114
Middle	.60	.823	± .312	.903	± .300
Upper	.30	.198	± .272	.099	± .257
Lower	.30	.360	± .166	.374	± .154
Middle	.10	-.410	± .272	-.341	± .239
Upper	.60	1.049	± .293	.967	± .250
Lower	.10	.006	± .112	.027	± .105
Middle	.45	.427	+ .307	.517	+ .293
Upper	.45	.567	± .282	.456	± .263
Lower	.33	.363	± .165	.375	± .159
Middle	.33	.222	± .271	.266	± .269
Upper	.33	.415	± .244	.359	± .226

APPENDIX B

Scale characters and selected descriptive statistics used in scale pattern analysis.

Appendix Table B1. Scale characters screened for linear discriminant function analysis of age 6_2 and 5_2 Yukon River chinook salmon.

Variable No.	Description
	First Freshwater Annular Zone
1	Number of circuli in 1st FW[1] annular zone
2	Width of 1st FW annular zone
3 (16)	Distance, scale focus (C0) to circulus 2 (C2)
4	Distance, C0 to C4
5 (18)	Distance, C0 to C6
6	Distance, C0 to C8
7 (20)	Distance, C2 to C4
8	Distance, C2 to C6
9 (22)	Distance, C2 to C8
10	Distance, C4 to C6
11 (24)	Distance, C4 to C8
12	Distance, fourth from last circulus of 1st FW annular zone to end of zone
13 (26)	Distance, second from last circulus of 1st FW annular zone to end of zone
14	Distance, C2 to end of zone
15	Distance, C4 to end of zone
16-26	Relative distances: (variables 1 to 13)/(variable 2)
27	Average interval between circuli: (variable 2)/(variable 1)
28	Number of circuli in 1st 3/4 of zone
29	Maximum distance between 2 consecutive circuli
30	Relative distance: (variable 29)/(variable 2)
	Freshwater Plus Growth Zone
31	Number of circuli in FW plus growth zone
32	Width of FW plus growth zone
	All Freshwater Zones
33	Total number of FW circuli
34	Total width FW zones
35	Relative width: (variable 2)/(variable 34)
36	Relative width: (variable 32)/(varible 34)

-Continued-

[1] FW = freshwater.

Appendix Table B1. Scale characters screened for linear discriminant function analysis of age 6_2 and 5_2 Yukon River chinook salmon (continued).

Variable No.	Description
	First Ocean Annular Zone
37	Number of circuli in 1st ocean annular zone
38	Width of 1st ocean annular zone
39 (57)	Distance, end of FW growth (EFW) to third circulus of ocean growth (C3)
40	Distance, EFW to C6
41 (59)	Distance, EFW to C9
42	Distance, EFW to C12
43 (61)	Distance, EFW to C15
44	Distance, C3 to C6
45 (63)	Distance, C3 to C9
46	Distance, C3 to C12
47 (65)	Distance, C3 to C15
48	Distance, C6 to C9
49 (67)	Distance, C6 to C12
50	Distance, C6 to C15
51 (69)	Distance, C9 to C15
52	Distance, sixth from last circulus of 1st ocean zone to end of zone
53 (71)	Distance, third from last circulus of 1st ocean zone to end of zone
54	Distance, C3 to end of 1st ocean zone
55	Distance, C9 to end of 1st ocean zone
56	Distance, C15 to end of 1st ocean zone
57-71	Relative distances: (variables 73-86)/(variable 38)
72	Average interval of circuli, 1st ocean zone: (variable 38)/(variable 37)
73	Number of circuli in 1st half of 1st ocean zone
74	Maximum distance between two consecutive circuli in 1st ocean zone
75	Relative distance: (variable 74)/(variable 38)
	All Ocean Zones
76	Width of second ocean zone
77	Width of third ocean zone (age 6_2 only)
78	Total width all ocean zones
79	Relative width: (variable 38)/(variable 78)
80	Relative width: (variable 76)/(variable 78)

Appendix Table B2. Group means, standard errors, and one-way analysis of variance F-test for the number of circuli and incremental distance of salmon scale growth zone measurements from age 6_2 and and 5_2 chinook salmon, Yukon River.

			Lower		Middle		Upper		
Age	Growth Zone	Variable	Mean	Std. Err.	Mean	Std. Err.	Mean	Std. Err.	F-Value
6_2	1st FW Annular	No. Circ.	10.9	0.01	10.4	0.01	10.2	0.01	12.579
		Incr. Dist.	123.4	1.57	124.0	0.95	113.0	1.42	29.198
	FW Plus Growth	No. Circ.	3.5	0.01	5.3	<0.01	5.9	0.01	205.727
		Incr. Dist.	29.9	0.82	51.9	0.63	60.4	1.35	245.418
	1st Ocean Annular	No. Circ.	27.2	0.03	26.1	0.02	24.8	0.03	48.331
		Incr. Dist.	462.9	14.36	469.4	7.44	443.7	16.47	15.215
	2nd Ocean Annular	Incr. Dist.	368.0	18.50	404.9	10.59	389.1	17.57	23.379
	3rd Ocean Annular	Incr. Dist.	1,208.2	94.84	1,263.7	39.73	1,208.7	59.45	18.661
5_2	1st FW Annular	No. Circ.	11.1	0.03	10.1	0.02	10.4	0.01	11.495
		Incr. Dist.	124.2	3.32	114.1	2.34	115.5	4.08	9.531
	FW Plus Growth	No. Circ.	3.6	0.02	5.8	0.01	6.0	0.03	84.669
		Incr. Dist.	35.3	2.52	57.6	1.02	62.7	4.16	76.911
	1st Ocean Annular	No. Circ.	24.8	0.06	24.8	0.04	22.3	0.05	38.765
		Incr. Dist.	432.4	25.59	443.0	24.15	402.8	23.79	17.619
	2nd Ocean Annular	Incr. Dist.	442.4	42.74	453.6	35.47	419.2	35.55	8.092